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Wiggling Worms: Using the Learning Cycle in an Elementary Classroom to Study Variation

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Graphic Work by Joe Taylor

USING THE LEARNING CYCLE IN AN ELEMENTARY CLASSROOM TO STUDY VARIATION

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ABSTRACT: In grades K-2, students are at an age when they start to look closely at living things around them. They can comprehend that while individuals may be of the same kind (i.e., kittens from the same litter), they possess differences. This article uses the learning cycle to engage students in making observations and measurements about plants and animals in order to help them understand "there is variation among individuals of one kind in a population" (AAAS, 1993, p. 107). *This article promotes National Science Education Standards A and C, and Iowa Teaching Standards 1, 2, 3, 4, 5 and 6.*

As a model of instruction, the learning cycle provides a structure to purposefully mentally engage students while connecting one activity to the next (Bransford, Brown & Cocking, 2000; Brown & Abell, 2007). The learning cycle begins with students experiencing the concept before developing a deep understanding of the concept. While starting with experiences before discussing the concept may seem counterintuitive, young children need concrete experiences to understand abstract concepts (Karplus, 1977). Importantly, learners of all ages learn better when beginning with concrete representations of concepts (Olson, 2008).

The learning cycle begins with an exploration phase where students experience working with a concrete objects, in this case, earthworms. The exploration phase is an opportunity for students to begin to wrestle with ideas that do not fit their prior concepts and also an opportunity for teachers to assess students' prior knowledge. Since students will oftentimes use their prior experiences to support their misconceptions, they will unlikely develop accurate science ideas on their own (Saunders, 1992). Therefore, the concept development phase of the learning cycle is crucial. If students are going to deeply and accurately understand science concepts, teachers must deliberately plan to explicitly develop concepts through activities that engage students in wrestling with their ideas and scientific concepts (Olson, 2009). In this article, the concept development phase focuses on expanding students' understanding of variation within a species to multiple organisms. The application phase of the learning cycle provides students with another opportunity to work with and experience the new science concept when they use the concept to solve a new problem. The application phase of this learning cycle includes inviting a guest speaker to help students understand all species have variability.

Exploration

This activity has been used by the authors in a second grade classroom, but could be modified for other elementary level classrooms. We begin by helping students see how earthworms vary by giving each student and their partner a few earthworms to observe. Before students handle the earthworms, we ask questions that require them to create and justify procedures for safe handling of animals and cleaning up accidents. For example, we ask,

A small styrofoam container of worms can be bought at a bait shop and stored in a cool location (e.g., refrigerator) throughout the unit. However, not everyone is a fan of earthworms! If you prefer to not use earthworms, try pill bugs (also known as rolly pollies) as an alternative.

- What do we need to do in order to keep the earthworms and ourselves safe?

We expect students to bring up they should wash their hands before and after working with the earthworms, not poke the earthworms, not cut the earthworms, and be kind to the earthworms.

If students do not mention an important aspect about working with earthworms, we ask a scaffolding question such as,

- What should I do before I handle an earthworm to make sure nothing harmful to earthworms is on my hands?

We provide students about 10-15 minutes to observe their earthworms. We have hand lenses and rulers available, but out of students' sight, for when students ask for them. Requiring students to determine and ask for tools that would enhance their investigations promotes problem solving, critical thinking, and effective communication.

Once students have had some time to observe their collection of earthworms, ask,

- What did you observe?

As students discuss, we place their responses on the whiteboard as a bulleted list, recording students' exact words. Recording students' thoughts verbatim, without the teacher interpreting or rephrasing to add meaning, conveys to students that their ideas matter. Beginning with students' words also ensures that you are working with language students understand (Vygotsky, 1986). While constructing this list, we add additional empty bullets to the board and use wait time (Rowe, 1974a, b) to nonverbally convey that we are waiting for another idea. We also use a host of positive nonverbal techniques: leaning forward, raising eyebrows, and smiling (Clough, et al, 2009) to encourage students to share ideas and create lists of similarities and differences on the classroom board.

Students typically list common features of earthworms such as: ridges, tiny hairs, different sections, etc. We encourage students to cite differences among the worms by asking,

- What differences did you notice among the earthworms?

Students typically struggle with this question and lead us into the next phase of our lesson.

Concept Development

To help scaffold student thinking we ask,

- What are some observations we could make of our earthworms to figure out the ways that these earthworms are the same and the ways they are different?

To have students consider the different types of observations and measurements they might make, ask,

- What tools do you think you will need?

When they respond with items such as rulers, strings, and hand lenses, ask,

- How do you plan to use those tools?

Students typically say, “We can use them to measure the worms and look at them closely.”

While students recognize they need to measure the worms, many students struggle with accurate measurement. Therefore, we conduct an in-depth “benchmark lesson” on measuring before students measure the earthworms. Benchmark lessons are occasions to teach students skills at a time when students will be using them to learn a concept (Ehteredge & Rudnitsky, 2003). If students have not already explored the concept of measurement and practiced measurement skills, we suggest proceeding with the benchmark lesson below. If your students are already proficient with measuring, you might skip ahead to the “Back to the Earthworms” section.

Measurement Benchmark Lesson

We set our earthworms aside for a while and ask students,

- What tools could we use to measure the length and width of an earthworm?

Since young students struggle with fractions and measuring, we use simplified measuring tools that only display whole-number markings.

We use a piece of yarn to represent the earthworm along with a ruler to demonstrate how to obtain a measurement. Importantly, we make intentional errors and ask questions to encourage student mental engagement. For example, we bunch up the yarn so that it is not lying flat next to the ruler. Here, students start to object, "The yarn isn't stretched out flat!" To which we respond,

- Oh, you're saying I have to lay the yarn out nice and flat next to the ruler. Why is that important?

While we could simply tell students they are "right" about their idea, asking them to explain why provides additional insight into their thinking and encourages active mental engagement. Furthermore, encouraging students to explain their thinking helps them become more confident, articulate, and critical thinkers.

Then we place the yarn so that the end of the yarn is well above the zero and students protest, "You have to line up the end of the string with the end of the ruler!" And once again we note the proper procedure and ask why it is important. If students do not raise objections, at each step along the way it is crucial to ask,

- What might be some reasons this measurement is not accurate?

Finally, we show students a meter stick and ask,

- Why might a ruler be more useful to measure the string than a meter stick?

Students often say, "the meter stick is too long" or "it doesn't measure it as well." We then ask,

- When would we want to use a meter stick instead of a ruler?

We point out the value of using a measurement tool that is closest to the size of the object we were measuring.

Next, we have students work with a partner to measure two different lengths of string. When we see groups where one student is doing the work and their partner is not participating, we continue to promote our student goals of cooperation and problem-solving by asking both students,

- What can you two do differently so that you each have role in completing this task?

When students are done making their measurements they share their measurements and we list them haphazardly on the board mixing up all of the measurements. If students do not protest, we ask,

- What do you notice about the measurements you made?

Generally, students will ask, "Which numbers are for which piece of string?" and we respond,

- We seem to be having trouble keeping track of the measurements when they are written this way. How else could we record this information so that we can more easily see which measurement goes with which string?

We then ask students how we could organize the measurements into a table to make them easier to read.

Depending upon students' past experiences, they may have some difficulty creating a table. If students need some help, we show them a sample table (nutritional information off a food label is often a handy source). We then ask them how they know what the numbers in this table mean and how they might be able to use this organization idea for their table. This scaffolding usually provides enough support for students to provide ideas as to how we might create a table.

Next we ask students,

- Why do you think we got different measurements for the same pieces of string?

And students generally respond that they made mistakes, forgot to start at zero, lost count, etc. We use this opportunity to connect this benchmark lesson to the earthworm investigation while introducing some inquiry concepts by getting out an earthworm for students to observe and asking:

- What might be some reasons why we would need to make more than one measurement?
- How do multiple measurements help us find out if we have made a mistake?
- If no one in the world has ever measured the length of this earthworm, how can we have confidence in your measurement?
- Who all should measure this earthworm?
- What would be some benefits of having more than one person measure this earthworm?

Back to the Worms

Following the measurement lesson, we have students return to their earthworms and collect data. To prepare for this activity and make a connection to the benchmark lesson we ask,

- How are you going to keep track of your earthworm measurements?

Students will usually respond that they should write things down in their notebooks, and then we ask,

- I remember how our measurements got confusing when we measured the book and the classroom. How should we organize all of this information so we can better keep track of the measurements?

Using the same process we used in the benchmark lesson, we use student ideas and questioning to create and edit a system for recording our measurements.

Once students have collected their earthworm data, students create and present a poster of their observations. When each group presents their observations we also have them share their conclusions about how earthworms are similar and different. Keep a record of each group's conclusions on the board. After all groups present, draw out the similarities and differences between groups' conclusions through questioning such as,

- What do you notice about the conclusions of group A compared to group B's?
- Based on everyone's investigations, what can we conclude about how earthworms are similar to each other?
- Based on our investigation, what can we conclude about how earthworms differ from each other?

To extend the concept that "there is variation among individuals of one kind in a population" (AAAS, 1993, p.107) beyond animals, have students use this same process with plants. This can be done by having students grow their own plants from seed and measuring the differences in the seeds or bringing in a collection of plants already grown (i.e., a collection of *impatiens* from a garden center). Using similar types of questions and teacher behaviors described previously, students can investigate their plants to identify if and how their plants vary, even though they are all the same kind of plant. By having students observe multiple organisms, we are using a deliberate sequence of activities where each logically connects to the previous activity in order to generate a pattern discernible to second grade students. We explicitly engage our students in a discussion with the purpose of identifying the common pattern between these different organisms (i.e., there is variation among individuals of a kind) by asking:

- Even though plants look the same, what are some differences you noticed when you looked closely?
- How are earthworms different from each other?
- What patterns do you notice between earthworms and plants?

Intentionally and explicitly drawing students' attention to this pattern ensures that students deeply understand the target concept, moving beyond simply completing activities towards understanding the big idea of variation within a species.

Application

The application phase begins with inviting a guest from an animal shelter, veterinarians' office, or pet store into the classroom so that students may observe a litter of puppies, kittens, rabbits, hamsters, mice, or if you are adventurous, snakes.

Preparing for A Guest

We prepare our classroom visitor by ensuring the visitor knows the purpose of their visit is for students to have an opportunity to observe the similarities and differences between the animals. Otherwise, they will likely come prepared with a presentation related to the animals, but not our objectives. Due to safety issues, allergies, and the type of animal brought in, it may be advisable for only the visitor to handle the animals and for students to make observations. To prepare our students we make sure they know:

- how to handle the animals (if they have an opportunity to do so),
- what types of observations to make,
- how to conduct those observations, and
- how to remember their observations.

Instead of simply telling students all of this information, we ask questions that require our students to create and justify plans for how to conduct the activity so that it is enjoyable, safe, and productive. We tell students that when the animals come to the classroom, their job is to compare them and notice how they are similar and different. Then we ask,

- What sorts of observations could we make to compare the animals?

To facilitate discussion, we place students' responses on the whiteboard as a bulleted list. We continue to prepare for our guest by asking a series of questions, such as:

- What materials do we need to prepare to make each of these observations?
- How do we safely and accurately use each of these materials?
- How will we remember our observations?
- How should we greet, interact with, and thank our guest?

Once the Guest Has Arrived

We facilitate our guest's interactions with our students by introducing our guest and reminding our students of what is expected of them during the guest's visit. We state,

- Tell me what we need to keep in mind while handling the animals.

After students clearly understand the expectations, we work with the guest to help students deepen their understanding of variation. We ask students:

- How do you think all the ______ will compare to each other?
- What are some observations you are making?
- What similarities and differences are you noticing?

After the Guest Has Left

To begin, we have students draw pictures of the animals and discuss with a partner their observations concerning what was similar and different between the animals. As their discussions begin to wane, we distribute whiteboards for students to work with their partner to create a list of their ideas. Next, we ask students what they notice about the list they have created and ask questions to promote a discussion of any patterns and anomalies they identify (e.g., How can you explain "fur color" appearing on both the similarities and the differences list?).

Importantly, this experience needs to be highly connected with the other experiences students have had in this learning cycle. To help students make connections between the experiences, we ask:

- When we looked at the same kind of animal or plant, what are some things you notice?
- What do you think we would see if we looked at a bunch of polar bears, frogs, or horses?
- What generalizations could we make about any living things of the same kind?

Conclusion

Implementing a learning cycle that is more than a loose collection of activities requires a teacher who understands what big science concept the cycle is progressing towards. Moreover, the teacher must purposefully and thoughtfully plan steps to logically and meaningfully build towards the target concept. Young children need numerous experiences to understand broad concepts such as variation within a species. Effective teachers can help students make connections between the stages of the learning cycle by asking questions which scaffold students. When teachers effectively scaffold, each step of the learning cycle adds a layer of complexity and generality. In addition, skills such as measurement can be taught to students during a learning cycle. When skills are taught right before students need them, students not only see a purpose for learning the skill, but tend to remember the skill longer because it is contextualized and used immediately. Thoughtfully considering how to scaffold students to understand concepts and skills can result in very meaningful learning.

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Lori and Jennifer *also co-authored the article Growing Minds: Planting a Lasting Seed using the Learning Cycle, published in the 38(1) issue of ISTJ.*